STUDY GUIDE FOR PUBLIC HEALTH PEST CONTROL

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about public health pest control. It will, however, help you prepare for your test.

Current information regarding recommended materials and methods should be obtained from your Extension Service office, your state extension publications, the state health department, and most importantly, the pesticide label.

Contributors include the Utah Department of Agriculture and Food and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State University Extension Service. The editor drew extensively from Pesticide Applicator Training Manual, Category 5, Aquatic Pest Control, Cooperative Extension Chemicals-Pesticides Program, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, New York; Pacific Northwest Vector Control Handbook, Cooperative Extension, College of Agriculture, Washington State University, Pullman, Washington; and Extension personnel in California and Washington.

The information and recommendations in this study guide are based on data believed to be correct. However, no endorsement, guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

Other topics that may be covered in your examinations include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.* U.S. EPA, USDA and Extension Service, revised 1991.

2. *Applying Pesticides Correctly: A Supplemental Guide for Private Applicators.* U.S. EPA, USDA and Extension Service, December 1993, Publication E-2474.

These books can be obtained from the Utah Department of Agriculture and Food or Utah State University Extension Service. Please contact your local Utah Department of Agriculture and Food field representative or Utah State University extension agent.

TABLE OF CONTENTS

INTRODUCTION 1
MOSQUITOS 1
SURVEY METHODS 3
CONTROL 4
LARVICIDES AND THEIR APPLICATION 6
FLIES OF PUBLIC-HEALTH IMPORTANCE 9
FLEAS 10
TICKS 11
SYLVAN RODENTS 11
DOMESTIC (COMMENSAL) RODENTS 11
THREATENED AND ENDANGERED SPECIES 19
WORKER PROTECTION STANDARDS 19
GROUNDWATER CONTAMINATION BY PESTICIDES 20

INTRODUCTION

Public-health pest control involves the control of insects or other animals that transmit diseases to man. These animals, which are capable of carrying a disease organism or parasite from one host to another, are called vectors. Public-health pest-control programs are usually directed against these vectors in the belief that control-ling the vectors will control the disease. The success of this approach is evident by the eradication of malaria and yellow fever from many parts of the world through control of the mosquito vectors.

Public-health considerations remain the basis for most vector-control programs, but other factors may also be important. For voters approving taxes to support a vector-control program, the immediate nuisance impact of mosquitoes, flies, and rodents actually may be of greater importance than the more remote public-health implications. Severe nuisance problems may have eco-nomic effects by discouraging tourism. Agricultural damage may result when vectors weaken livestock or transmit disease to them.

Successful control of a vector pest involves several steps. The pest must be accurately identified, and its biology must be adequately understood. With this information, the next steps -- evaluation of the problem and choice of a control strategy -- may be undertaken. Implementation of the control measures selected is the final step. If this step is to be successful, it must be based on knowledge and understanding of the pertinent technology and safety precautions.

The communities supporting a vector-control program will be more cooperative and satisfied if they understand the general methods and goals of the program. The entire control program must reflect the current legal situation. This part of vector control should not be ignored.

MOSQUITOES

Mosquitoes belong to the order Diptera and the family Culicidae. They are an abundant group of flies that are a dominant pest of man and domestic animals, acting as vectors for malaria, filariasis, yellow fever, dengue fever, encephalitis, and dog heartworm. The larval stages are aquatic, and the adults differ from all other flies by having scales on their wings and usually on their body as well.

Most mosquitoes belong to five genera, *Anopheles, Aedes, Psorophora,Culiseta* and *Culex*. Mosquitoes belonging to the genus *Psorophora* are generally vicious biters and behave like the floodwater species of the genus *Aedes.*

Members of genus *Anopheles* are vectors of malaria and are known as "malaria mosquitoes." Although all species of this genus are believed to transmit malaria, only two species are known to transmit it in the United States.

The floodwater mosquito, genus *Aedes,* is an important pest mosquito, some being vicious biters. *Aedes* is the most common pest mosquito in Utah. The mosquito *Aedes aegypti* is a potential carrier of yellow fever and dengue fever, but this species doesn’t occur in Utah.

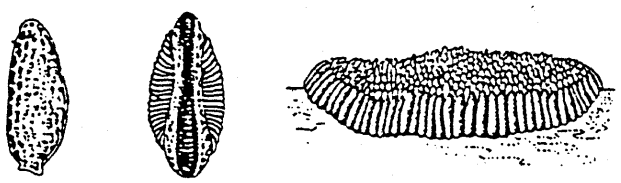
Culex tarsalis feeds on the blood of birds, large mammals and humans and is the most important vector of Western equine and St. Louis encephalitis. In the spring, it will feed on birds, but it feeds on mammals during the summer.

Female adult mosquitoes of most species suck blood, and a blood meal is required for egg production in these species. Adult females of a few species and males of all species feed on nectar and other plant juices.

Eggs

Generally the female lays her eggs on or near water. The eggs of genus *Aedes,* which are laid separately near water, only hatch when they are flooded, and they may hatch after being dry as long as two years or more. Incubation periods vary, depending on species and temperature, but generally are 16 to 24 hours.

Eggs laid singly



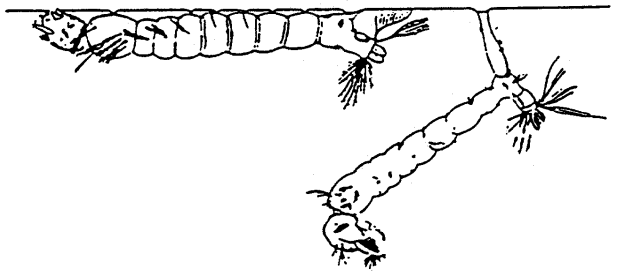
Without float With float *Egg raft*

The eggs of *Anopheles sp.* are laid separately directly on the water surface and are provided with floats on the sides of the egg.

Genus *Culex* lays its eggs stacked vertically in rafts, which float on the surface of the water.

Larvae

The larvae or “wigglers” of most species feed on algae and other organic material. Larva of a few species are predaceous and feed on other mosquito larvae. The larvae breath at the surface of the water through a breathing tube (siphon), with the exception of genus *Anopheles,* which lacks a breathing tube (siphon) but has a pair of spiracular plates. Larvae of the genus *Anopheles* may be distinguished from the larvae of other genera because they lay parallel to the surface of the water while breathing. The larvae of other genera of mosquitoes hang down at an angle from the surface of the water.



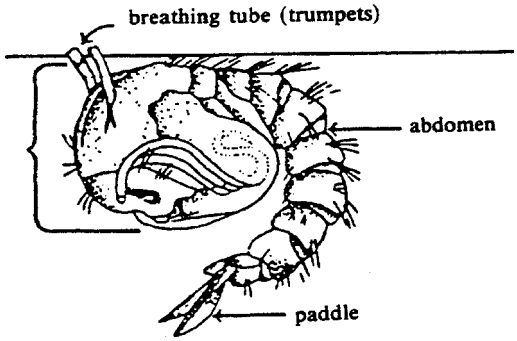
Anopheline *Culicine*

Mosquito larvae grow by a series of four molts, where the entire skin is shed. After the fourth molt, the pupa appears. The period of time between molts varies and is largely dependent on the quantity and quality of food and environmental conditions. Warmer water temperatures shorten this period of time.

Because mosquito larvae don’t have to depend on aeration of the water for survival, a very large number of larvae can live in a relatively small amount of water, even if it’s foul.

Pupae

Mosquito pupae or "tumblers" are comma-shaped and have a pair of breathing tubes or "trumpets" near the head rather than the single siphon near the tail that the larvae have. Pupae don’t feed but remain quite active. Unless disturbed, this stage remains at or near the water surface. Pupae are more resistant to many insecticides than are larvae. The pupal stage lasts only from two to four days, depending on temperature. During this time, the adult mosquito is forming within the pupal skin.

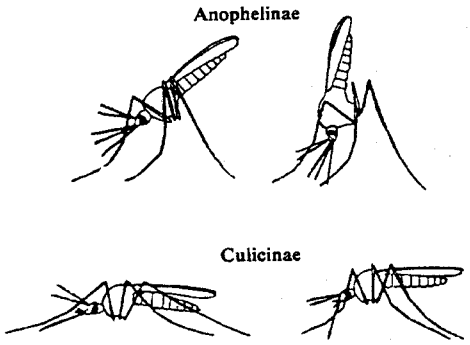


When emergence time approaches, the pupa becomes less active. Within a short period of time, the pupal skin splits and the adult mosquito emerges, rests on the water surface until the skin hardens and the wings dry, and eventually flies away.

Adults

Mosquitoes act as vectors of several very important human diseases: malaria, yellow fever, filariasis, dengue, encephalitis, and other diseases. The adults of two major groups, (*Anopheles* and *Culicidae*) may be identified by the angle their body makes with the surface they are resting on. The *Anopheles* rest with their proboscis and abdomen in a line at an angle to

the surface. The *Culicidae* rest with their proboscis and abdomen at an angle and their abdomen parallel to the surface.



There are three primary factors that attract mosquitoes to their host. In order of importance, they are moisture, warmth, and carbon dioxide (CO_2). Amino acids and estrogens are capable of enhancing these primary factors. This is thought to be why some people seem to be more attractive to mosquitoes than others.

The flight range of mosquitoes interests mosquito-control districts; it helps them determine the possibility of reinfestation from an area outside the district where control measures aren't taken. The flight range varies with species, time of year, wind direction, and the distance the mosquitoes must fly to find warm-blooded animals on which to feed.

Studies have been done in the rice-growing area of Yolo County, California, with *Culex tarsalis* marked with fluorescent material and recaptured at various distances from their point of release using $C0_2$-baited traps which attract only the blood-seeking female. It was found that dispersion takes place in all directions if the wind speed is less than two miles per hour. (The greatest distance of recapture upwind was 2-3/4 miles!) If the wind speed is above four miles per hour, the dispersion is downwind with very little movement upwind. If the wind is above six miles per hour, the effective distance of dispersion doesn't increase appreciably, because such high winds discourage flight.

A similar study done in the Sacramento Valley with *Anopheles freeborni* recorded flights as far as 17.5 miles, with a small portion of the female population migrating into the foothills at a distance of ten miles.

As can be seen, these mosquitoes can fly for great distances, which makes them hard to control.

SURVEY METHODS

One of the most important elements of a successful control program is the survey. Surveillance is the detection of the mosquito problems, the species involved, their numbers, and their location. The information provided by survey programs and a thorough knowledge of the mosquito's biology, habits and habitats will provide a sound basis for control. Each problem is different and requires a different approach. Besides providing the immediate information on whether the particular problem warrants control and the methods of control to be employed, analysis of survey data on a long-term basis will determine whether the control program is effective. The decision of where to apply the control measures should always be based on surveys.

LARVAL SURVEYS

Since the larval and pupal stages of mosquitoes live in water, it's customary to examine the water to determine either the abundance and/or the species of immature stages. A record of the life stages present when surveys are made is important, because pupae and eggs are not readily controlled by chemicals. A long-handled water dipper is used to survey for larvae and pupae. The surveys must be made to determine in which waters there are larvae, because the mere presence of water doesn't necessarily mean the presence of mosquito larvae. No water should be treated unless it contains larvae. The frequency of examination for the survey is related to the length of time and the season necessary for larvae to mature.

During the early spring, larval development may take from two to three weeks, but during warm summer temperatures, eggs may hatch and adults emerge in seven to ten days. Because the larvae grow rapidly, the timing of surveys is exceedingly important. As soon as there is free water from the melting snow and ice, the overwintering eggs hatch into larvae. Mosquito larvae from these overwintering eggs can develop into adults as early as May.

ADULT SURVEYS

There are three main methods of surveying the adult mosquito population: landing counts, light traps, and $C0_2$ traps. Supplementary methods include pigeon traps; resting stations, both artificial and natural; and truck-mounted traps moving through mosquito areas.

Landing counts involve rolling up a pant leg or shirt sleeve and collecting the number of mosquitoes that land during a given period of time. These collections give an index of the numbers of the biting population and identify the species causing the most annoyance. The same procedure should always be followed so comparisons between counts can be made.

When surveying mosquitoes for vector potential or for further identification, the mosquitoes which land may be captured with a killing tube or an aspirator. A killing tube is merely a tube or vial whose bottom inch is filled with a killing agent such as ethyl acetate and covered with cotton. When the mosquito lands, the killing tube is placed over the mosquito until it dies. When mosquito populations are high, capturing specimens with an aspirator is a quicker and more effective method than using a killing tube. An aspirator consists of a 12-inch- long, one-half-inch-diameter tube with a siphon hose attached to one end. A screen is fitted between the tube and the hose to prevent inhalation of the specimens. Mosquitoes are drawn into the aspirator as the collector draws air through the hose. Specimens are then transferred to a killing tube for further identification. The landing-count method samples that portion of the female mosquito population which is seeking blood.

Light traps are a second and typical method of making a mosquito adult survey. This is a metal cylinder with a protective metal cap and containing a light bulb, which serves as an attractant. A fan inside the cylinder blows the insects down into a killing jar or some other collecting container. Both males and females are collected. The number of individuals and species collected gives an index to mosquitoes present in a given area. Not all species are attracted to the light, so the light trap method has limitations.

The light trap should be mounted with the light about six feet from the ground and 30 feet or more from buildings, in open areas near trees and shrubs. Strong winds, competing light sources, or industrial smoke or fumes reduce the light trap's effectiveness. A timer or electric eye can be used to turn the light on and off. Collections should be made daily, and the catch identified and recorded.

$C0_2$ (carbon dioxide) traps are similar in construction to the light trap. The difference is that an insulated container with small holes in the bottom is used either in addition to or in place of the light. The blood-meal-seeking female follows the $C0_2$ trail produced by the conversion of dry ice into carbon dioxide gas.

CONTROL

Once the situation has been surveyed, a control plan may be formulated. The word "abatement" is often used rather than control since the usual program is designed to reduce the number of mosquitoes to an acceptable level, rather than trying to kill the last remaining individual. Such a practice would be very expensive as well as environmentally unacceptable, in that excessive drainage or use of chemicals would be called for.

An abatement situation may be relatively simple or rather complex, depending on the scope of the problem. There may be a localized adult problem, for instance in a Boy Scout camp, where the adults have emerged from woodland pools that have since dried up. A good residual application of pesticide may be all that is necessary. On the other hand, a community may be surrounded by grass meadows that are flood-irrigated. In this case, an integrated abatement program, including water management, physical changes, biological control, and chemical application,

would be necessary. Total reliance on pesticides is seldom the best approach. Each situation is different and must be handled differently. Small-area abatement situations can be adequately handled by an individual; large abatement programs must be under the strict supervision of a trained director.

Larval Control

Under most conditions, control procedures against mosquitoes are most effective and economical when designed to eliminate larvae. Since mosquito larvae live only in water, water management is a means of control. Where water can't be managed, chemical control may be used. Water management is normally thought of as being a more permanent control measure, whereas chemical control is normally only a temporary measure. The presence of water doesn't always mean that mosquito larvae are present.

Water management on a large scale involves the alteration of the land surface, drainage ways, or ponds and lakes in order to eliminate excess surface water which may serve as mosquito-breeding habitats. Water management should be especially considered when a mosquito problem-area requires many chemical treatments each year. Although the initial cost of water management may be higher, it may prove less expensive in the long run than repeated insecticide applications.

The control of mosquito populations by the use of water-management techniques is directed toward the aquatic stages. The three basic principles involved in water management are:

1. The removal of excess surface water within five days, thereby eliminating the mosquito breeding habitat.

2. Increasing the amount of standing water to create a suitable habitat for predaceous fish and/or creating a means of access for these fish into and out of mosquito-breeding areas.

3. Increasing the movement of water in the mosquito-breeding area and thus creating stress conditions for the larval and pupal mosquitoes.

Water management on a small scale involves the individual homeowner, but this is important to the success of community programs. Large numbers of mosquitoes can be produced in local, small water accumulations. Especially with species that fly only short distances, homeowners may be able to alleviate their own and their neighbor's problem by the following steps:

1. Eliminate all temporary water containers such as tin cans and old tires.

2. Tightly cover all cisterns, water barrels cesspools, and septic tanks. Don't allow sewage or other liquid wastes to collect on the ground.

3. Empty, wash and refill bird baths and animal watering containers at least once a week.

4. Keep rain gutters clean and flat roofs dry.

5. Drain or fill stagnant pools or swampy places.

6. Make weekly examinations of the containers in which plants are grown in water. If larvae are seen, dump the water, wash the plant roots and the containers, and refill the containers with clean water.

7. Keep the margins of small pools or ponds clear of plants that emerge through the water.

8. Fill all tree holes with cement, or drain them.

Water-management techniques include the general maintenance of existing drainage ditches, streams, and rivers and is essential in any upland water-management program. The elimination of debris that normally accumulates in these watercourses is necessary to avoid creating mosquito-breeding habitats.

Restoration of some rivers, streams, and ponds is important in maintaining a system that is free of mosquitoes. Many rivers and streams have a flood plain which may accumulate standing water after a heavy rain, thereby providing suitable mosquito-breeding habitats. Successful restoration projects involve the removal of any excess surface water by

providing outlets to and for tributary streams. Restoration of ponds usually entails the removal of aquatic vegetation and/or the excavation of silt to a depth that will maintain an adequate population of fish and other mosquito predators.

Another source-reduction technique involves filling in or grading mosquito-breeding areas. Landfills function similarly on a larger scale. The removal of standing water from cans, bottles, tires, and wrecked automobiles such as those found in junkyards -- or preventing such situations -- may substantially reduce mosquito populations. Around dwellings, mosquitoes may be reduced by periodically removing the water from birdbaths, wading pools, or other receptacles which may hold water.

Biological control has already been discussed under water management. Mosquito fish, *Gambusia affinis,* are predatory on larvae and pupae and can be introduced into breeding areas, where they reproduce rapidly. State and local fish and wildlife agencies should be notified before movement or placing non-native fish. Other naturally occuring predators such as diving beetles and dragonfly larvae can be preserved by careful planning and reduced chemical application.

LARVICIDES AND THEIR APPLICATION

TYPES OF LARVICIDES

Insecticides that kill larvae and, less often, pupae can be applied to water in which the aquatic stages live. Different formulations are used, depending on the situation and application equipment. Formulations include granulars, emulsifiable concentrates, solutions and oils. Application equipment varies from simple granule spreaders or compressed-air sprayers to air-planes, again depending on the situation.

Extreme care and adequate supervision are essential when using chemical pesticides to control mosquito larvae. In some areas, water containing mosquito larvae in the early spring may produce only one brood; hence, one well-timed application of a suitable pesticide in the spring is sufficient. In some communities, other species produce several broods throughout the summer months, and a pesticide may be required to control each brood. Because of these differences in mosquito biology, a continuing survey is necessary to determine when the larvae are present in sufficient numbers to justify control procedures.

In large ponds and lakes, almost all larvae are found among the marginal emergent vegetation, so little or nothing will be gained by treating the open water. The pesticides should be applied only to the weedy margins. By limiting the treatments to these areas, the danger of harming fish and other desirable organisms will be reduced.

GRANULAR LARVICIDES

Granular formulations sink to the bottom of larval breeding areas and release the toxicant into the water. Granular formulations can be applied as a pre-emergence treatment over ice in marshes or woodland pool areas in the very early spring. At this time, all areas of the marshes are accessible. Later, after the ice melts, coverage of the marsh may be difficult. When the ice and snow melts, the insecticide is released.

Granular materials are also advantageous for spot-treating small pools in sensitive areas such as bird sanctuaries, where a broadcast treatment would be environmentally unacceptable. When aerial applications must be made to large areas under heavy foliage, granulars are especially effective, since they won't stick to the foliage, but will bounce down through it and into the water. Most of the pesticide will reach the target instead of a large proportion remaining on the leaves, as would be the case if a liquid spray were used.

OILS

Light, highly refined oils designed especially for mosquito control are applied to the water surface and spread in a thin film over the water. They act on both larvae and pupae either by suffocating the insects or by poisoning them as they take in toxic vapors through their breathing tubes.

APPLICATION

Application rates vary from one to ten gallons per acre, depending on the type of oil, the vegetative

cover, etc. The oils are relatively safe to other forms of wildlife and can be used in sensitive areas where other larvicides are not suitable. Oils are usually used to control pupae.

Oils are usually applied by compressed-air sprayers, power sprayers, or aerial equipment.

OIL SOLUTIONS

Oil solutions are often supplied by the manufacturer in highly concentrated form. Many of the chemicals used against mosquito larvae are so effective that only a small amount is required for control. One-twentieth of a pound (.05 pound) per acre may be all that is needed or recommended. It's hard to apply this small amount uniformly over an area, so the manufacturer's concentrate is often diluted with oils for easier handling. Oil-based solutions don't evaporate as quickly as water emulsions, so they are preferable when the applicator depends on drift to help cover the area to be treated.

Oil solutions are often applied to small breeding areas with compressed-air sprayers or portable mist blowers and to larger areas with mist blowers or aerial equipment.

EMULSIFIABLE CONCENTRATES

Emulsifiable concentrates are designed to be diluted with water. The insecticide will mix with the water in the breeding area and control larvae present. They can be applied with hand equipment such as compressed-air sprayers or with power sprayers. Aerial application can also be used, but since the water-based mixture in tiny droplets evaporates rather quickly, this type of equipment is generally not as satisfactory.

GROWTH REGULATORS

Similar in formulation and application techniques to other larviciding chemicals. However, they differ in their mode of action. Other chemicals usually used kill the mosquito larvae or pupae, but growth regulators interfere with the normal development of the insect. The mosquito larva may never transform to a pupa, or molting may be affected. Growth regulators are desirable in that they have little or no effect on other wildlife occurring within the breeding area.

APPLICATION EQUIPMENT

Granule applicators, whether large or small, all work on the same principle. They are containers with adjustable openings in the base through which a controlled amount of granular insecticide may pass. They may be manually operated or power-assisted. Some may be equipped with agitators or auger feeds to help produce a uniform flow.

HORN SEEDERS

The simplest device for applying granules is the horn seeder. The horn seeder is comprised of a canvas bag which is slung over the shoulder with a tapered, telescoping wand or tube located at the lower front corner of the bag. Granules are dispersed as the operator's arm and wand move in a horizontal figure-eight fashion. Application rates may be altered by adjusting the opening at the base of the wand or by changing the speed at which the operator walks.

CYCLONE-TYPE SPREADERS

The cyclone-type spreaders are the second type of manually operated granular applicators. These are cylinders with an adjustable slot in the base through which granules fall onto a rotating disc and are dispersed by centrifugal force. This disc is rotated by gears, which are activated by turning a crank handle. The rate of dispersal may be altered by controlling the size of the slotted opening or by changing the walking speed of the operator.

Both the cyclone-type spreader and the horn seeder are commonly used in treating small, isolated breeding areas such as woodland pools.

BLOWER-TYPE APPLICATORS

The power-assisted, blower-type granular applicators have feed tubes which meter the granules into the blast of an air blower. These blower-type spreaders may be back-pack size or truck-mounted. The speed of the air blast ranges from 75 to 150 miles per hour. Similar blower-type spreaders are also used in helicopter delivery systems where the forward air speed of the aircraft isn't high enough to provide adequate pressure for proper distribution of the granules. In fixed-wing aircraft, where the payload is greater, ram air-type spreaders are used which

require no power other than the air being driven back by the propeller.

Liquid larvicides most often used are oils, oil solutions or emulsions. The choice of formulation is influenced by the application equipment, the distance the material is expected to drift, the safety of the formulation, and other such factors.

Liquid-application equipment used in larviciding varies from simple hand equipment to truck-mounted sprayers and specially equipped aircraft. The largest equipment isn't always the best. Rather, equipment should be chosen to fit the situation. A description of commonly used types follows:

COMPRESSED-AIR SPRAYERS
One of the most common sprayers for treating small areas is the one- to three-gallon compressed-air sprayer. The air in the upper portion of the spray tank is put under pressure by a hand pump, and the pressure created forces the spray through the nozzle. Compressed-air sprayers are used for applying larvicides to small breeding areas such as catch basins or woodland pools.

HYDRAULIC SPRAYERS
In hydraulic sprayers, the spray mixture is taken into the pump, put under pressure, and forced through the nozzle. In some sprayers, pressures of up to 600 psi may be reached. Hydraulic sprayers range in size from a back-pack with a trombone sprayer to those which are truck-mounted. This equipment is most often used for treating larger mosquito-breeding areas.

AERIAL SPRAYERS: Liquid spray systems can be mounted on either fixed-wing or rotary-wing aircraft and make larviciding of large or otherwise inaccessible areas easy. Regular spray-delivery systems can be nozzled to apply the rather small quantities needed per acre.

ADULT CONTROL

While larval control is the preferred method of treatment when possible, there are situations where it can't be used or where adulticiding supplements a larviciding or integrated program. Sometimes a larval population escapes control, and the biting adults must be reduced. If a small village is surrounded by many acres or miles of breeding area, usually larviciding isn't economically possible. The same holds true for small areas such as outdoor theatres, camps, racetracks, parks, and individual properties. Sometimes an adult population that has been only a nuisance will become a public- health problem as a disease vector and must be drastically reduced. All of these situations require adult mosquito control.

Space Treatments

Insecticides used in space treatments are applied as fine droplets in the form of fogs, mists, or fine sprays. The droplets float about in the air, settling very slowly and, depending on their size, drifting over long distances to expose adult mosquitoes to the insecticide. Drift is both a help and a hindrance. It helps control mosquitoes over a large area, but the application must be planned to avoid highly sensitive areas, for instance bee yards, fish ponds or parking lots, especially if the droplets are large enough to settle into these areas.

Space treatments are temporary, becoming ineffective as soon as wind has carried the droplets out of the area. Winds exceeding five or six miles per hour or temperatures of more than 85 degrees F. often reduce the effectiveness of the insecticide. Application is best made in early morning, early evening, or at night, when the air is calm and cool. Larger droplets that are deposited on foliage may give short residual action.

Application equipment for space treatments varies from hand-carried equipment to truck-mounted or aerial delivery systems. Different types of units include ultra low volume (ULV) applicators, thermal foggers, cold foggers, mist blowers, and aerial dispersal systems.

1. In **ULV equipment**, low-pressure/high-velocity air and low-pressure liquid insecticide concentrates are introduced into a swirl chamber, where shearing action of the air produces extremely fine droplets. Droplet size is relatively uniform and controllable. ULV with ground equipment is becoming

increasingly popular for space treatments. Units are either portable or truck-mounted. Treatments rely on a gentle wind (one to five miles per hour) to carry chemical to the target area.

2. **Thermal foggers** produce an insecticidal fog formed by momentarily exposing the spray concentrate to heat. A heavy cloud of smoke is produced, which contains very fine particles of insecticide. Thermal fogs are very susceptible to wind and thermal air currents. If applied during unfavorable conditions, such as during a hot day, the fog may be carried up and over the target adults and be ineffective. It's usually better to do applications during the evening or at night, when the fog is more likely to be held close to the ground. Thermal fogging was once the main form of mosquito adulticiding, but because the thick clouds can be hazardous to traffic, it has been replaced with ULV.

Foggers range from small hand-held units that use blowtorch propane bottles for their heat source to larger units that must be carried in a pickup truck. Units that use the hot exhaust gases from jeep, truck or helicopter exhausts have been successfully used.

3. **Cold foggers** have characteristics similar to thermal foggers, except that the fog results from a mechanical breakup of the spray concentrate.

4. **Power sprayers or hand-held compressed-air sprayers** are used to apply residual adulticides to perimeter vegetation, sometimes referred to as barrier spraying.

5. **Aircraft** can quickly and effectively apply space sprays over large areas. This is especially desirable if a public-health problem such as encephalitis suddenly appears, or if a large population of nuisance mosquitoes escapes. Because of the high application speed, ULV techniques can be easily used. However, drift problems will be magnified. Small-orifice conventional nozzles or specialized high-rpm spinning nozzles are used.

All adulticide applications are much more effective when a temperature inversion exists in the lower 30 feet of the atmosphere.

Storm-sewer or catch-basin treatment is an important part of a community program.

In cities with catch basins along the edges of streets, surveys indicate that many basins hold enough water to produce large broods of house mosquitoes. The application of petroleum oils or granular insecticides to these catch basins is useful but isn't always the complete answer to this type of mosquito control. A single shower may produce enough runoff to flush out the larvicide.

Dilute residual sprays can be applied with compressed- air, knapsack or powered hydraulic sprayers. Concentrated residual sprays are applied by mist blowers.

FLIES OF PUBLIC-HEALTH IMPORTANCE

Flies belong to the order Diptera and have two distinguishing characteristics in the adult: (1) one pair of wings (or none) and (2) halteres, which are small knob-like structures located behind the wing. Mosquitoes discussed earlier also belong to this order of insects.

Flies have complete metamorphosis (egg, larva, pupa and adult). A few species retain eggs within the body until they are hatched, then they deposit living larvae.

Generally, the legless, wormlike larvae occupy a different habitat from the adult and also have different feeding habits. The time required to complete the life cycle varies with the species and depends on a variety of environmental factors.

Through sheer numbers, domestic non-biting flies can be a nuisance to people in their work, home or recreational environment. Because flies can be

associated with human excreta, they can become involved in enteric disease cycles. Besides being annoying, fly species that do bite may transmit diseases such as tularemia. Many species of flies deposit eggs or larvae on the flesh of living animals. These larvae invade the flesh of the host, producing a condition known as myiasis. Myiasis occurs commonly in some sylvan and domestic animals but not often in man. Listed below are general characteristics of representative fly species.

THE HOUSE FLY -- *Musca domestica*
The adult of this non-biting species occurs commonly in homes. The time for development from egg to adult is from eight to 20 days, depending on a variety of environmental conditions. The larvae are found in many types of moist, warm organic material, such as animal manure, human excrement, or garbage that may rot. Adult flies feed on decaying organic material as well as milk and food intended for human consumption. Adult flies are usually found within one mile of their larval habitat, although they are capable of dispersing over greater distances. Temperature, light and humidity all affect fly activity.

LESSER HOUSE FLIES -- *Fannia ssp.*
These species and house flies are generally the most prevalent flies found within the home. The adult flies hover in midair in the center of a room or enclosure, lending the name "hover fly" to this group. The larvae live in decaying vegetable and animal matter, including human excrement, animal manure, and rotting grass piles. The average time for larval development is seven days. The larvae of this genus have caused myiasis in man.

Survey Methods
Domestic fly surveys are conducted to indicate the relative population densities of the various fly species in an area. Surveys for adult flies are generally considered more reliable than larval surveys.

The three most common survey methods used to determine species composition as well as population densities for domestic flies are:

- **!** Fly traps in which adult flies are collected and identified.
- **!** Fly grills in which a standard slat grill is placed over natural attractants, with the flies being counted and identified.
- **!** Fly reconnaissance surveys in which flies are caught and identified from natural resting places.

BOTTLE AND BLOW FLIES -- *Calliphoridae*
The adult flies of this widespread group enter homes, especially in the fall, where they create a nuisance. The larvae usually feed on animal tissue, but they will infest fresh and decaying plant refuse when animal tissue isn't available. The larvae of many species cause myiasis in animals and humans.

STABLE FLY -- *Stomoxys calcitrans*
This biting fly is found wherever man and his domestic animals occur, attacking both. Larvae are found in decomposing straw, hay or weeds but rarely in human excrement or animal manure. The time for larvae development averages three to four weeks.

BITING MIDGES OR PUNKIES --
Culicoides and *Leptoconops*
These tiny adult flies (sometimes referred to as "no-seeums") occasionally cause severe annoyance to man and animals. The larvae live in aquatic or semiaquatic situations or in moist soil. One species is a vector of blue tongue in cattle and sheep. Other species may be vectors of tularemia. Suitable survey techniques are larval and pupal count from around edges of fresh or brackish water and light traps.

BLACK FLIES -- *Simuliidae*
Only the females in this group are capable of taking a blood meal. The larvae and pupae are found clinging to rocks in the rapids of clear streams. This group occasionally causes severe annoyance to animals (rarely to man) in the vicinity of fast-moving streams. At least one species is known to be a mechanical vector of tularemia. Suitable survey techniques are adult landing or biting counts on animals and larval counts from fast- flowing streams.

DEER AND HORSE FLIES -- *Tabanidae*
Like the mosquitoes and black flies, only the females of the tabanidae feed on the blood of man and animals. Their bites inflict painful injuries. The eggs

are deposited near water, allowing the larvae to mature in damp soil and litter. Species of at least one genus serve as mechanical vectors of tularemia. Suitable survey techniques are adult landing or biting rates on animals and soil larval sampling.

FLESH FLIES -- *Sarcophagidae*
The adult flies of this large group normally don't enter homes. The larvae of most species live in animal tissue, although some live in animal manure, especially dog feces. They are involved in human intestinal syiasis.

Many Diptera not listed here can be of significant public health importance, but the above eight groups plus the mosquitoes are the most important to vector control personnel in Utah.

FLEAS

Fleas are small, wingless insects with a narrow, laterally compressed body. Through their bites, they cause severe annoyance to people and their pets. The majority of the species infest smaller mammals, and while most have developed a high degree of host specificity, a few are found on a variety of hosts. Fleas have complete metamorphosis. The life cycle varies with environmental factors; it may be completed in as few as two weeks or as long as a year or more. Females oviposit on the host, where the eggs soon drop, or they deposit eggs directly onto nesting material. The wormlike larvae feed on debris in nests or in animal quarters. Adult fleas can survive long periods without feeding. Flea species which may be found in Utah include the cat and dog flea, the human flea, and the northern rat flea. Problems with fleas are often intensified when pets are removed from the premises.

The human flea and a closely related species have been found in Utah. Their bites can cause a dermatitis. Besides feeding on man, they attack a wide variety of hosts, including swine, dogs, and ground squirrels.

The northern rat flea is the species most often found on domestic rats and mice in Utah. It doesn't readily feed on man.

Fleas serve as the alternative host for the dog tapeworm. Many of the flea species that infest sylvan animals transmit the plague organism from animal to animal and from animal to man. Thus, they play a role in maintaining a low level of plague in wild rodent populations. The most significant plague hosts in Utah are rock or ground squirrels. Their principal flea is *Diamanas montanos.* It's an aggressive parasite and will readily bite other animals and people.

TICKS

Ticks are known vectors for Rocky Mountain spotted fever, Colorado tick fever, tularemia, and tick-borne relapsing fever. Some species are capable of producing a toxic paralysis. Ticks are divided into two main groups, the hard ticks (family Ixodidae) and the soft ticks (family Argasidae). The hard ticks possess a dorsal shield of scutum; this distinguishes them from the soft ticks, which lack this structure.

IXODIDAE -- HARD TICKS
Hard ticks create problems for man in Utah, either through disease transmission or through discomfort caused by their bites. They are present from spring through summer in a variety of outdoor habitats. They rest on grasses and low vegetation, where they attach themselves to animals or people that brush against the plants.

The female takes a blood meal, drops from the host, and deposits several thousand eggs on the ground, few of which survive to adults. The six-legged larvae hatch within a couple of weeks and locate a small-animal host. After obtaining a blood meal, the larvae drop from the host, molt, and emerge as eight-legged nymphs. The nymphs repeat the process of feeding and moulting until they become adult ticks. The adult ticks of both sexes require larger animals or man as hosts. This life cycle usually requires two or more years to complete, and each stage normally feeds on a different host. These species are most abundant in brushy areas along trails and along abandoned log roads. Temperature and humidity play a significant role in tick development and activity.

ARGASIDAE -- SOFT TICKS

The preferred hosts for most species of soft ticks are birds and small mammals. These ticks feed often but for brief periods of time and are usually found in the nests of their hosts. Some species are nocturnal feeders. Man is most likely to come in contact with this group when occupying cabins or buildings where small mammals have their nests or when camping in the immediate vicinity of animal burrows, nests, or bedding areas.

The female of the soft tick may lay several small groups of eggs, with a blood meal needed before each oviposition. In some species, the larvae moult to the numphal stage without feeding. Five to six nymphal molts occur before the adult stage is reached.

SYLVAN RODENTS

Wild or "sylvan" rodents such as prairie dogs or ground squirrels may infect man directly with diseases like tularemia, leptospirosis and plague. They also may serve as reservoirs for diseases transmitted by ectoparasites, such as tick-borne relapsing fever, Colorado tick fever, Rocky Mountain spotted fever, plague and tularemia. Deer mice, woodrats, and some species of squirrel may enter buildings and thus add structural damage and annoyance to the threat of disease transmission. Some wild rodents are severe agricultural or silvicultural pests. For one or more of these reasons, wild rodents occasionally become the target of vector-control efforts.

Identification of the offending species is the first step toward control. It may be necessary for the Utah Department of Health to determine which species are involved in disease programs. Field identification may be accomplished with a good field guide to mammals.

Control may take one of several forms: physical exclusion, trapping, poisoning, shooting, or use of repellents. In a particular situation, the best control measure will depend on the species of rodent, the location of the problem area, the surrounding biological community, the size and distribution of the pest population, etc.

DOMESTIC (Commensal) RODENTS

Domestic (commensal) rodents have coexisted with man in his habitats for centuries. They have eaten man's food and wastes and have shared his living quarters. They have become man's chief vertebrate pest because of their great reproductive capacity and their ability to adapt to new environments. Aside from eating man's food, the domestic rodents are involved in contamination of foods by defecation, destruction of building structures by their gnawing habits, and transmitting diseases and harboring parasites of medical and veterinary importance. Some of the diseases that rodents are directly or indirectly involved in conveying to man are plague, murine typhus, infectious jaundice, ratbite fever, food poisoning, poliomyelitis and rabies.

The three main domestic rodents found in Utah are the Norway rat, the house mouse, and the deer mouse. The roof rat is common in other regions, and a brief discussion of it is also included.

NORWAY RAT

The Norway rat is the common domestic rat in Utah. It has coarse hair and close-set ears, and its muzzle is blunt. Its tail is dark on the top and light on the underneath side. The tail is shorter than the combined length of the head and body. The fur is gray-brown on the back and gray-white on the belly. The adults weigh between 12 and 20 ounces and are 7.5 to ten inches in head-and-body length. The tail length is between six and 8.5 inches. The feces are capsule-shaped and about three-fourths inch long.

Norway rats can be found in warehouses, farm buildings, houses, sewers, rubbish, dumps, woodpiles, and building foundations. They are good climbers. On their hind legs, they can reach a height of 18 inches, and they can jump 24 inches vertically. Rats are good swimmers and stay afloat for 72 hours. The Norway rat has relatively poor vision but keen senses of smell, touch, taste and hearing. The sense of touch is served by long whiskers on the snout. (Domestic rats and mice run close beside a wall where these sensory hairs touch to give the animals information about their

surroundings.) The home range is often 100 to 200 feet.

Norway rats and other domestic rodents are mainly nocturnal, but they may go about in undisturbed places during the day. They feed on virtually anything edible. Norway rats are unable to vomit. They must drink water to survive.

ROOF RAT

The roof rat is smaller than the Norway rat. Serious pest populations of roof rats are confined along the southern and western coastal areas of the country. Roof rats have large, membranous ears and a sharply-pointed muzzle. The unicolored tail is usually longer than the head and body combined. The adult head-and-body length is between six and 8-1/2 inches, while the tail ranges between seven and ten inches in length.

The adult weighs from eight to ten ounces. The feces differ from those of the Norway rat in that they are about one-half-inch long and are spindle-shaped.

HOUSE MOUSE

The most common household rodent is the house mouse. This mouse resembles the roof rat in that they both have large ears, pointed muzzles, and slender bodies. However, the house mouse is a great deal smaller. The tail is unicolored, has little hair, and is about as long as the head and body combined. The adult mouse can be distinguished from a young roof rat because the head and feet of the mouse are distinctly smaller in proportion to its body size. Adults weight one-half to three-fourths ounce and are 2-1/2 to 3-1/2 inches long in head-and-body length. The tail measures between three and four inches long. The feces are one-eighth to one-fourth inch long and are rod- shaped.

Although house mice are commonly found living in man-made structures, they are also well adapted to living outdoors. They are common inhabitants of grassy fields and cultivated grain crops. These wild populations often move into buildings when weather becomes severe. The house mouse has poor vision and is colorblind. However, the mice have keen senses of smell, taste, hearing and touch.

Mice use their sense of smell to locate food items and recognize other individual mice. More research is needed on the value of repellent and attractant odors, but taste appears able to override most odor effects. House mice have acute hearing. They readily respond to unusual noises as a means of detecting and escaping danger. However, house mice become accustomed to repetitive, ordinary noises, and, as a result, their activities may be more visible than those of rats.

An important sensory factor is touch. Mice use their long, sensitive whiskers on the nose and above the eyes as tactile sensors. The whiskers and guard hairs enable the mice to travel easily in the dark, along runways close to walls. House mice feed on a wide range of foods, although cereals seem preferred over other items. In particular, the germ of grains is favored by most mice. As supplemental diet items, mice often show preference for foods high in fat and protein, such as lard, butter, nuts, and dried meats. House mice are sporadic feeders, nibbling bits of food in various locations throughout their range.

Small amounts of food often are taken many times at many places. Mice have two main feeding periods, at dusk and just about dawn. Because of their small size, mice must feed several times during a 24-hour period. This means that they will be active day and night. Their range is normally ten to 30 feed from the nest. Their nest is lined with soft materials such as cotton or paper and may be built in walls, cabinets, upholstered furniture, or other convenient spaces. Their urine and droppings mark the trail for others. Mice are poor swimmers.

DEER MOUSE

The native deer (white-footed) mouse occasionally invades buildings adjacent to fields or woodlands. Deer mice are about the same size or slightly larger than house mice. Deer mice can be differentiated from house mice by a distinct, bicolored tail (upper portion brown-gray, lower half white). Deer mice characteristically have small ears and eyes and a relatively short tail.

The deer mouse is the most common host of the Hantavirus, but other small animals may carry the

disease. Hantavirus is a viral illness transmitted from saliva, stool or urine of infected animals. Once these waste products dry, the virus can become airborne. Infection usually results when the virus is inhaled. The illness is described as a severe respiratory illness that results in death for about 50 percent of its victims.

Use extreme caution or avoid activities associated with exposure to mouse or small-animal droppings.

DETERMINING RODENT PRESENCE

Rodents provide numerous signs that indicate their presence. These include:

Sounds -- Gnawing, clawing, climbing in the attic, and various squeaks are commonly associated with house mice and rats.

Droppings -- Droppings are left along runways, near shelters, and in other places that rodents frequent. Droppings of mice are smaller and usually harder than those produced by rats. However, insects and other rodents may produce similar droppings.

Urine -- House mice urinate at intervals along well-used runways. Occasionally, they also will form small mounds (urinating pillars) that consist of a combination of grease, urine and dirt. Wet and dry rodent urine stains will fluoresce under ultraviolet (black) light.

Smudge marks -- Dirt and oil from the fur of the rodent may sometimes leave smudge marks on pipes and beams. Smudge marks left by rats are much more conspicuous than those produced by house mice.

Gnawing marks -- Wood chips about the consistency of coarse sawdust are produced by the gnawing of house mice. Most gnawing occurs around baseboards, doors, windows and frames, and kitchen cabinets. Recent gnawings on wood are light in color, darkening with age. The size of the tooth marks left in the wood can help distinguish the presence of rats or mice.

Pet excitement -- Pawing and excitement of cats and dogs can indicate the presence of rodents. Pets respond most commonly when the premise has been invaded only recently.

Odors -- Rodents produce characteristic odors. With experience, the musky scent of house mice can be differentiated from those produced by rats.

ESTIMATING RODENT POPULATIONS

There's no easy or certain way of estimating rodent numbers. The techniques used most often are "reading" of signs, actual observations of rodent activity, or census of feeding. However, after considerable experience, a rat-control worker can usually detect the presence of rodents, even in fairly low numbers.

Rat sign can provide a very rough estimate of density. After a thorough search for rat sign in attics, basements, around foundations, and behind stored materials, use the following criteria:

Rat-free or low infestation -- No sign. Probably invaded by rats only recently, or the habitat won't support many.

Medium population -- Old droppings and gnawing common, one or more rats seen by flashlight at night. No rats reported observed during the day. There are probably ten rats or more in each general areas where one rat is seen at night.

High population -- Fresh droppings, tracks, and gnawing present; three or more rats are seen at night. Rats are seen in daylight.

PHYSICAL CAPABILITIES OF COMMON COMMENSAL RODENTS

The Norway rat can:

- Gain entrance through any opening that is larger than one-half inch square.
- Climb both horizontal and vertical wires.
- Climb the inside of vertical pipes that are 1-1/2 to four inches in diameter.
- Climb the outside of vertical pipes and conduits up to three inches in diameter.
- Crawl horizontally on any type of pipe or conduit.
- Jump vertically as much as 24 inches.
- Jump horizontally 48 inches on a flat surface.
- Jump horizontally at least eight feet from an elevation of 15 feet.
- Drop 50 feet without being seriously injured.
- Burrow vertically in earth to a depth of four feet.

- Climb brick or other rough exterior walls that offer footholds.
- Climb vines, shrubs and trees or travel along telephone or power lines.
- Swim as far as one-half mile in open water, dive through water plumbing, and travel in sewer lines.
- Gnaw through a wide variety of materials, including lead sheeting, sun-dried adobe brick, cinder block, and aluminum sheeting.

The house mouse can:

- Gain entrance through openings slightly larger than one-fourth inch in diameter.
- Jump 12 inches from a flat surface.
- Jump against a wall or vertical surface and use it as a springboard to gain additional height.
- Jump from a height of eight feet without injury.
- Run up almost any rough vertical surface, including brick walls, wood, weathered sheet metal, wire mesh and cables.
- Run horizontally along insulated electrical wires and small ropes.
- Travel upside down along one-fourth-inch hardware mesh.
- Swim capably, if it needs to. House mice don't tend to dive below the surface, as do rats.

RODENT CONTROL

Rodent control may involve the use of several control measures, including cleanup or sanitation, rodent-proofing, use of toxicants and traps, and other methods. Sanitation is important in a successful rodent-control program. The elimination of shelter, food
and water can mean the difference between success or failure in controlling rodents. Good housekeeping practices are important. A program of routine cleaning should be set up and followed. Such areas as obscure corners, shelves, under and in cabinets, work tables, lockers and equipment shouldn't be overlooked. Eliminate rubbish piles. Keep refuse in rat-proof containers until it's removed.

Rodents need a safe place to hide. Inspect the building to identify potential harborages. Rodent-proofing within the building in such places as stairways, cabinets, lockers, machinery, double walls, false ceilings and floors, boxed-in pipes and conduits may be needed. These sites not only serve as shelter but also as nesting and breeding sites.

Proper storage practices are necessary to eliminate harborages. Rodent damage to stored materials can be greatly reduced if good storage practices are followed. In commercial storage areas, products should be on pallets at least eight inches off the floor, 18 inches from adjacent walls, not stacked more than six feet wide, and separated by an aisle at least 12 inches wide.

These practices reduce harborage areas, permit inspection and cleaning, and allow for installation of appropriate control measures. Outside, keep grass, weeds, and other vegetation near buildings closely cut. Eliminate lumber, rock piles, rubbish, and old equipment. Fill in old rat holes and burrows with earth. Store items at least 18 inches off the ground and away from walls or fences. Rodent-proofing involves the removal of all possible entrances into buildings. Exclusion practices are often hard because of the habits and behaviors of rodents. Rats and mice are quite agile and capable of entering through extremely small openings. Openings of one-fourth to one-half inch are big enough for mice and rats respectively. Rats can enter building through drains and toilets. Both rats and mice are capable of gnawing through wood, fiberboard, and many plastics. Exclusion or rodent-proofing is hard, but it can be achieved through modification of existing buildings or in the design of new buildings. In pest-control work, it isn't always possible to do extensive rodent-proofing; however, you should see that some is done so your control program will have a chance to succeed.

The bottoms and edges of doors that don't fit closely can be built up with wood so there is no opening greater than a half-inch, and covered with metal cuff. Openings around pipes, windows, holes in walls, foundation vents, and ventilating fans can be covered with screening or hardware cloth (19 gauge) or sheet metal (20 gauge or heavier). Holes in masonry walls should be cemented shut. It's impossible to list every situation or place that needs rodent-proofing. You'll

need to rely on your ability to observe every possible entry to the building.

Rodent competition

There is some competition between the various commensal rodents. Partial separation between rats and mice has been reported in grain stacks, with house mice feeding in the lower areas and rats in upper portions. The smaller size of house mice gives them access to places that are not available to rats. Upon direct confrontation, rats will kill mice.

Pest-control operators have observed that when a building is freed of rats, house mice often move in or increase in numbers. This may be due to reduced competition, but it often results from mice being able to enter and colonize areas that have been made rat-proof, since potential mouse infestations may follow rat-control activities. This should be anticipated by the pest-control operator. House mice are highly competitive against deer mice. Where house mice are present, deer mice will rarely be found.

Rodenticides

Both single-dose and multiple-dose anticoagulant rodenticides are available for rat and mouse control. Although finished baits are available in a wide variety of types, some persons trained in rodent control prefer to mix their own baits with rodenticide concentrates.

When possible, finished baits should be used because they don't require that the applicator handle the concentrate, a more hazardous material.

Pre-baiting

Mice and rats are cautious feeders and may reject new foods or eat only small amounts for the first several days. Acceptance of a toxic bait can be increased by conditioning rats to feed on a non-toxic version of the same food or "pre-bait."

Pre-baiting is highly recommended before using a single-dose toxicant. After the untreated baits are being eaten regularly, begin the use of treated baits. Pre-baiting may be necessary for two to five days to achieve maximum benefits. The amount of pre-bait eaten helps to determine the amount of toxic bait needed. All uneaten pre-bait should be removed when the toxic bait is applied.

If acceptance of pre-bait is poor, toxic bait should not be applied. Poor acceptance may be corrected by changing bait material or its placement.

Single-dose rodenticides

Single-dose rodenticides will give a quick knockdown of rat and mouse populations, and they may be preferred where rats and mice are abundant or where it's hard to get rats and mice to accept a bait for several days in succession because of competing food items. When rats or mice consume a sublethal amount of an acute toxicant such as zinc phosphide, red squill or ANTU, "bait shyness" or "poison shyness" may result. Because of this bait-rejection problem, these three single-dose poisons shouldn’t be used more than twice a year at a given location, and preferably only once. Strychnine acceptance in baits is very poor, usually giving inadequate control.

Multiple-dose rodenticides

Multiple-dose anti-coagulant rodenticides are generally considered much safer than single-dose rodenticides, although red squill has a good safety record. Bait shyness doesn’t occur when properly formulated anti-coagulant baits are used. With the exception of brodiafcoum, anti-coagulants cause death to mice and rats after they are fed on for several days. These latter rodenticides are capable of causing death after a single feeding, however, death doesn’t occur for several days.

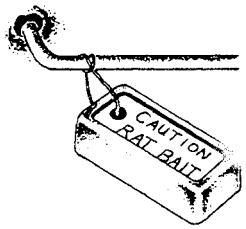
When anti-coagulant rodenticides are used, fresh bait must be made available to rats and mice continuously for at least two weeks or until all signs of feeding cease.

Bait selection and placement

Anti-coagulant baits are available in several types. Grain baits in a meal or pelleted form are often available packaged in small plastic, cellophane or paper packets. These "place packets" keep baits fresh and make it easy to place baits into burrows, walls or other locations. Rats and mice will readily gnaw into these bags to get at an acceptable bait.

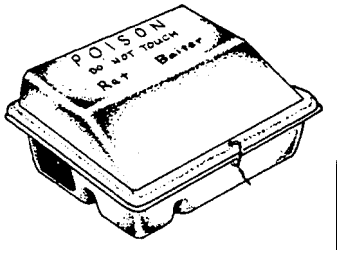
Anti-coagulant baits that have been formulated into paraffin blocks are available from various manufacturers. These blocks are especially useful in sewers or where moisture may cause loose-grain baits to spoil. Acceptance by rats and mice of paraffin-block baits is usually less than acceptance of loose-grain baits. Sodium salts of anti-coagulants are available to be mixed with water. Since rats require water daily, they can be drawn to water stations in some situations. Although mice require little water to survive, water baits used where moisture is scarce can be an effective supplement to other control measures.

Water bait



Paraffin bait block

Use of bait stations (boxes) protects rodenticides from weather and provides a safeguard to people, pets, and other animals. Bait stations should have at least two openings about 2-1/2 inches in diameter for rats or one inch in diameter for mice. The bait boxes should be large enough to accommodate several rats or mice at one time, depending on the problem-rodent species. Bait boxes should be placed next to walls, with openings close to the wall, or in places where rats or mice are active. Rats usually feed in one place, so relatively few bait stations may be needed if correctly located. On the other hand, mice feed in many places and won't travel great distances.



Bait station

Many bait stations may be needed for mice. Space them no farther than ten feet apart, and preferably closer. Baits or traps need to be placed where mice are living, such as in wall spaces, on pallets of feed, etc. All bait boxes should be clearly labeled "Rat Bait" or "Mouse Bait," as the case may be.

Write down the locations of all bait stations so that inspections can be made rapidly and baits replaced quickly. At each inspection, smooth the surface of the granular baits so that new signs of feeding will show readily. Examine paraffin bait blocks for signs of rodent-gnawing. Replace moldy, wet, caked or insect-infected baits with fresh ones. Maintain records of activity indicating where baits have been disturbed, dead rodents found, and droppings or tracks observed.

Tracking powders

Tracking powders are toxicants in dust formulations that are placed in the rodent's runway, near their harborages, or in their burrows, where they travel through them. The dust is picked up on the feet, and the rodent swallows the tracking powder when it grooms itself. Tracking powders can be useful when other toxicants, such as baits, are not accepted or when there is a surplus of food.

Don't use tracking powders where the rodent or air currents may carry the powder onto human-food surfaces or food-preparation areas. Use bait stations in these situations. Tracking powders can be applied with a shaker on runways, with a dust pump in burrows, or with a duster on wall voids.

Fumigants

Fumigants are often used to control rodents in their burrows in outdoor situations, and sometimes in rail cars and on ships. The operation can be expensive, if the structure has to be tarped. Fumigants are highly toxic to people and animals, and they must not be used in any situation that might expose the occupants of a building to the vapors. Because of the hazards involved with fumigants, only persons licensed for fumigation pest control should use fumigants in any situation involving buildings or other structural enclosures.

Resistance to rodenticides

When genetically immune individual rodents survive a rodenticide treatment, they pass the resistance ability to their offspring. Since many rodent populations have

a rather high number of individuals that are less susceptible to most rodenticides, the development of resistance has been a serious problem.

The development of resistant rodent populations is related to the amount of selective pressure that is applied to them. As a result, more thorough rodent control programs can be expected to develop the greatest problems with rodenticide resistance. Pest-control operators should constantly be aware of resistance as a source of control failures. Where rodent-control efforts are regularly applied, periodic shifting of different baits (active ingredients) is advisable.

Rodenticide safety precautions

Certain general safety precautions should be followed besides those appearing on the labels of products. Consider all rodenticides dangerous, and place baits where only rodents can get them.

There are no known rodenticides that don't present some degree of hazard to animals other than rodents. Persons who formulate rodent baits for their own use should use extreme care in handling the materials. Rubber gloves, an apron, and a proper respirator should be worn. Wash thoroughly after preparing baits, using soap, a brush, and plenty of water. Clean all bait-mixing utensils thoroughly, and use them only for bait preparation. Whenever possible, it's best to buy prepared or ready-to-use baits, thus reducing risks involved in handling concentrated toxicants. Label all bait containers and stations clearly with appropriate warnings. Store unused bait and concentrates in a locked cabinet, out of reach of children or animals.

Follow the label directions on all rodenticide products carefully. Pick up all dead rats and mice after a poisoning program. Handle the carcasses with tongs or rubber gloves. Dispose of large numbers of rats and mice by incineration or burial. With only a few, especially mice, place them in a plastic bag, close it tightly, and dispose of it with other refuse.

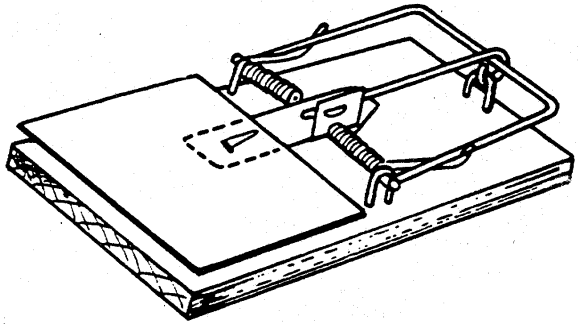
Remove and destroy all uneaten bait at the end of the poisoning period. Never leave single-dose baits exposed for more than three or four days.

Traps

Trapping can be an effective method of controlling rats and mice, but it requires more skill and labor than most other methods. Trapping is recommended where poisons seem inadvisable, and it's the preferred method to try first in homes, garages, and other small structures where there may be only a few rats present. Trapping has several advantages:

1. It doesn't rely on inherently hazardous rodenticides.
2. It permits the user to view his success.
3. It allows for disposal of rodent carcasses, thereby eliminating odor problems, which may occur when poisoning is done within buildings.

Snap-traps are generally more effective than cage traps. Simple, inexpensive, wood-based snap-traps are readily available. For rats, bait the traps with peanut butter, chocolate candy, dried fruit, or a small piece of bacon tied securely to the trigger. For mice, use bacon, nuts, hard sugar-candy, gumdrops, or peanut butter. Leaving traps unset until the bait has been taken at least once reduces the chance of rats or mice becoming trap-shy.

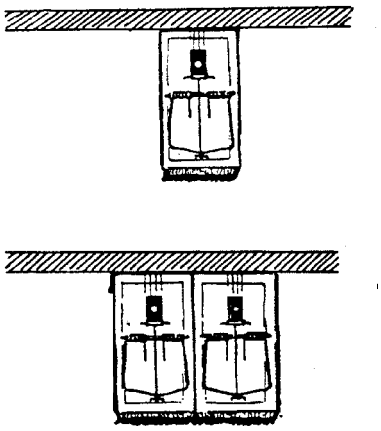


Enlarged trigger trap

Place traps close to walls, behind objects in dark corners, and in other places where rat and mouse activity has been seen. Place the traps so that the rats and mice following their natural course of travel (usually close to a wall) will pass directly over the trigger. Traps can be set on ledges or on top of pallets of stored materials, if mice are active in such locations. To determine whether rodents are present in a particular area, lightly dust the area with talcum powder. If rodents are present, their tracks will be visible in the dust. Cover all areas of escape with

traps. Record the number of traps placed on each job. In food plants, map the location of each trap. This enables someone else to follow up an account, if necessary.

Use enough traps to make the campaign short and decisive. Since mice seldom venture far from their shelter and food supply, traps should be placed from three to ten feet apart in areas where mouse activity is noted. Place them within 20 feet of each other for rats.



Single trap set with trigger next to the wall. The double set increases your success.

Glueboards

Glueboards are an alternative to traps. Glueboards catch and hold mice and rats trying to cross them in much the same way flypaper catches flies. Like traps, glueboards need to be placed along walls where mice and rats travel. Don't use them where children, pets, or desirable wildlife can contact them. Glueboards lose their effectiveness in dusty areas, and temperature extremes may affect the tackiness of the adhesive.

Glue board

Although rats and mice are easily frightened by strange and unfamiliar noises, they quickly become accustomed to regularly repeated sounds and are often found living in grain mills and factories. Ultrasonic sounds, those above the range of human hearing, have very limited use in rodent control because they are directional and don't penetrate behind objects. Also, they lose their intensity with distance. There is little evidence that sound of any type will drive established mice or rats from buildings. Several types of electromagnetic devices have also been marketed recently with claims of repelling rodents effectively or causing them to behave abnormally.

Scientific tests of many such devices have shown that they failed to control rodents as claimed by their advertising.

THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. This act requires EPA to be sure that these species are protected from pesticides.

Formulation of the Utah Threatened and Endangered Species/Pesticides Plan is a cooperative effort between federal, state and private agencies and producers/user groups. It's a basis for continuing future efforts to protect threatened and endangered species from pesticides whenever possible. Furthermore, this plan gives agencies direction for management policies, regulations, enforcement and implementation of threatened and endangered species/pesticide strategies.

EPA has therefore launched a major new initiative known as the Endangered Species Labeling Project. The aim is to remove or reduce the threat to threatened and endangered species from pesticide poisoning. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESA is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The FWS will determine jeopardy to threatened and endangered species and report to EPA. EPA and FWS will work cooperatively to be sure their responses to pesticide users are consistent and to provide necessary information. The Utah Department of Agriculture and Food is acting under the direction and authority of EPA to carry out the ESA as it relates to the use of pesticides in Utah.

Maps will show the boundaries of all threatened and endangered species habitats in affected counties. The maps identify exactly where, in listed counties, use of active ingredients in certain pesticides is limited or prohibited. Product labels will be updated as necessary. The updated labels will reflect any additions or deletions to the project. Because EPA's approach to the protection of threatened and endangered species was in the proposal phase at the time this guide was published, any and all of the above information on threatened and endangered species is subject to change and may not be valid.

WORKER-PROTECTION STANDARDS

This final rule, was proposed in 1988 and substantially revised standards first established in 1974. It affects 3.9 million people whose jobs involve exposure to agricultural pesticides used on plants; people employed on the nation's farms; and in forests, nurseries and greenhouses. The standard reduces pesticide risks to agricultural workers and pesticide handlers. The standard is enforceable on all pesticides with the Worker Protection Standard labeling. The provisions became fully enforceable in January 1995.

Agricultural workers in Utah now have a far greater opportunity to protect themselves, their families and others. These workers will know, often for the first time, when they are working in the presence of toxic pesticides, understand the nature of the risks these chemicals present, and get basic safety instructions.

Among the provisions of the rule are requirements that employers provide handlers and workers with ample water, soap and towels for washing and decontamination. Also, emergency transportation must be made available in the event of a pesticide poisoning or injury. The rule also establishes restricted-entry intervals -- specific time periods when worker entry is restricted following pesticide application -- and requires personal protection equipment (PPE) for all pesticides used on farms or in forests, greenhouses and nurseries. Some pesticide products already carry restricted re-entry intervals and PPE requirements; this rule raised the level of protection and requirements for all products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training, which handlers have easy access to pesticide-label safety information, and that a listing of pesticide treatments is centrally located at the agricultural facility. Finally, handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

GROUNDWATER CONTAMINATION BY PESTICIDES

Utah has put into effect a comprehensive and coordinated approach to protect groundwater from pesticide contamination.

Formulation of the Groundwater/Pesticide State Management Plan is a cooperative effort between federal, state, and private agencies and producers/user groups; it provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan gives agencies direction for management policies, regulations, enforcement and implementation of groundwater strategies.

While it's recognized that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of crops, enhance outdoor activities, and give relief from annoying pests, the Utah Department of Agriculture and Food is authorized by the U.S. Environmental Protection Agency (EPA) to enforce the protection of groundwater from pesticides. Product labels will be updated as necessary.

The Utah Department of Agriculture and Food, in concert with cooperating agencies and entities, admonishes strict compliance with all pesticide labels, handling procedures and usage to protect groundwater in the state.

Groundwater can be affected by what we do to our land. Prevention of groundwater contamination is important, because once the water is polluted, it's very hard and costly to clean up. In some instances, it's impossible, especially if the water is deep underground. City and urban areas especially contribute to pollution, because water runoff which contains pesticides runs into drainage tunnels, then into a river or an underground stream which drains into the river. For more complete information about what groundwater is and where it comes from, read the study manual "Applying Pesticides Correctly." Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers. Sandy soils allow more pollution than clay or organic soils, because clays and organic matter absorb many of the contaminants.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establishes a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, a pesticide can be registered by the EPA. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that isn't degraded or broken down and carry it to the groundwater via leaching.

The major factors which influence the amount of contamination which can get into water are the chemicals' persistence in soil, retention time or time it remains in the soil, the soil type, the time and frequency of the application(s), soil moisture, placement of the pesticide, and the ability of the chemical to persist after it's in the aquatic environment. Each of these factors will influence the amount of pesticide which can leave the root zone or soil surface and percolate to groundwater.

Although some pesticides may have a high absorption quality, when they are applied to sandy soil, they will still migrate to the water table because there are no fine clay particles or organic matter to hold them. The management and use of pesticides is up to the individual applicator and/or land owner as to whether safe practices are used. Water is one of our most valuable resources; we must keep it as pure as possible.